

DESIGN AND DEVELOPMENT OF BIO-DIGESTED SLURRY LIFTING MACHINE, FOR PADDY STRAW BASED DRY FERMENTATION BIOGAS PLANT

JASVARINDER CHALOTRA¹ & SARBJIT SINGH SOOCH²

¹Senior Research Fellow, School of Renewable Energy Engineering, College of Agricultural Engineering & Technology,
Punjab Agricultural University, Ludhiana, Punjab, India

²Senior Research Engineer, School of Renewable Energy Engineering, College of Agricultural Engineering & Technology,
Punjab Agricultural University, Ludhiana, Punjab, India

ABSTRACT

The Paddy Straw Biogas plant is an up growing technique for producing biogas and removing pollution caused by burning of paddy straw. A batch system Biogas plant produces biogas on an average of 3 to 4 months regularly if once filled fully with paddy straw, but later it becomes difficult to remove material from inside of the plant. The main objective of the research is to develop a lifting machine for removal of bio digested slurry from the plant operating on paddy straw as a feeding material. An underground 10 feet deep cemented walled plant, having 10 feet diameter and 3 feet opening on the top covered by a MS cover bolted with nuts, with a capacity of 16 quintal paddy straw mix and 4 quintal cow dung has been used. A system is developed on the basic of above given dimensions that are simple and easy to operate that fits into pocket of farmers. The lifting machine so developed is compared with other operational methods like, Conveyers and Hydraulic systems, and it was found that system so developed is best among all, economical and easily affordable.

KEYWORDS: Paddy Straw, Dry Fermentation Biogas Plant, Bio Digested Slurry & Bio-Digested Slurry Lifting Machine

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I. INTRODUCTION

At present, all crop residues like paddy straw, potato tendrils, vegetable plants and tree leaves have been burned in the fields just to make the fields clean for the next crops in short time. This becomes the major problem as the level of pollutions and accidents are due to smoke produced by burning. These crop wastes can be valuable fuel for kitchen / power generations [1]. Although some of the crop residues are being used for power generation using thermal method, but it creates atmospheric pollution and a huge amount of ash for which disposal becomes a headache. An open field burning of crop residue is a common practice in many countries [2]. Such crop residues may be digested by anaerobic means for the production of methane gas as a fuel for the kitchen as well as for power generation. The latest method of anaerobic digestion, dry fermentation of organic wastes requires little labor and produces a large amount of methane for a period of 3-4 months. The digested material so produced from such anaerobic digestion is good quality manure, ready for use in the fields. Rice husk used as a valued added raw material for different purposes. It possesses various properties that make them suitable for bioethanol production [3]. The ash of rice husk has properties of bricks and is used in road constructions and other useful purposes [4, 5]. The carriage of digested material is not difficult, as it can be carried in baskets for loading in tractor trolley.

Attempts have been made at "School of Renewable Energy Engineering, Punjab Agricultural University, and Ludhiana"; to construct a masonry structure, for removing material that is a major problem now a days.

Section II elaborates the purpose of the machine, so developed. Section III gives the material used, construction of plant and process of development lifting machine. This research work ends up with results and conclusion in Section IV and V respectively.

2. PURPOSE OF BIO-DIGESTED SLURRY LIFTING MACHINE

2.1 Purpose

The initial paddy straw based biogas plants so developed at PAU; Ludhiana was having one drawback that, it was very easy to fill the plant with required materials to produce gas. But later it becomes mandatory to empty the plant in order to reload it with material so as to start the production of gas once again. The major issue in the project was that the concept of removal of bio-digested slurry from the plant was not added and the slurry was removed manually which lead the laborer to go inside the dome to collect material. In this one laborer took the material from inside in a bucket and passed it to another standing outside the dome, which was ultimately a time consuming and complicated process that used to take 3 to 4 days to remove the entire slurry. Apart from them as the depth increases removal process also becomes difficult as it increases the physical load and it has created a hectic situation for the same. To overcome this problem of removal of bio-digested slurry from plant the necessary steps were taken and research started in developing such a machine that could decrease the work load as well as available at low cost. This research ends with the development of a “Lifting Machine” completed the project in all aspects.

3. DESIGN & DEVELOPMENT OF MACHINE

3.1. Procurement of Material

Paddy straw was procured from the research field of “Punjab Agricultural University, Ludhiana, Punjab” after the harvesting of crops. The material for the bio digested slurry lifting machine was developed by an Engineer according to requirements and assembled inside the University for Trials of the machine.

3.2. Construction of Plant

The details of plants are given in Figure.1. The life of the structure is more than 20 years and its major advantage is that the whole structure is underground, which has little effect by low temperature in winter. The process of Dry Fermentation is a batch process, once the digester is loaded and activated, it would produce biogas for a period of 3-4 months.

Unlike conventional plant that was made water tight the digester in developed plant has been constructed and made completely air tight. In the conventional biogas plants, the digestion took place in the presence of large amounts of water and the gas bubbles are free to move only in the vertical upward direction, but in a system so developed the quantity of water is very little that made gas bubbles free to move in all directions. If the digester is not made air tight storage of gas becomes impossible. Feeding of the plant with paddy straw and small quantity of cattle dung in layers is done as shown in Figure.1.

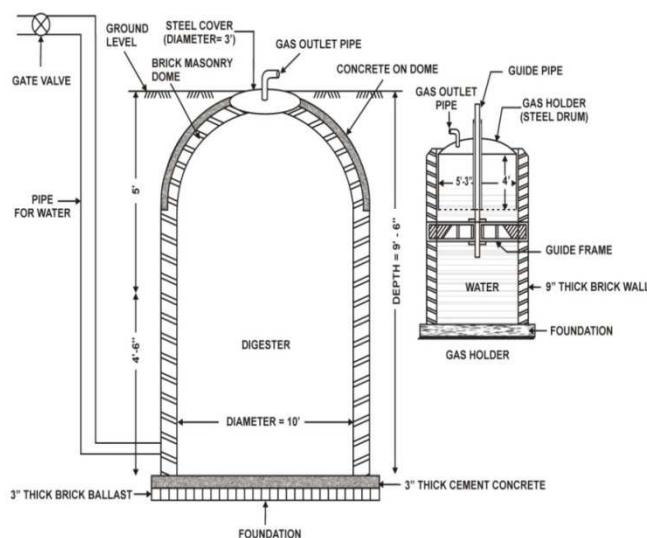


Figure 1: Dimensions of Dry Fermentation Biogas Plant

Quantity of Paddy Straw =1.60 MT

Quantity of Cattle Dung =0. 40 MT

A pipe connected at the bottom is used to add water in the plant and to saturate the paddy straw. The production of actual gas starts after 7 to 10 days and a steel gas holder is connected to digester to supply gas to the burner. The amount of gas so produces lies in the range of 4 to 5m³/day, i.e. 3 to 4 cylinders of the LPG / month and this process continues for 3 months. The Plant is reloaded with material after 3 months by firstly emptying it. The digested material collected from the plant is rich, organic humus which can be used as organic manure. The approximate cost for the construction of the plant is 1.20 lakh.

Paddy straw based Dry fermentation biogas plant is a new technique that is available in Punjab Agricultural University, Ludhiana. The success report of working plants along with production of methane and capacity of plant at different locations of Punjab is available at PAU.

3.3. Methods and Machines Developed before Developing Lifting Machine

Earlier a Screw Press machine having worms of length 10 feet long was tried for removal of bio-digested slurry from the plant (Figure.2). But this method was limited to chopped and small size paddy straw. The long size straws stop the working of the machine. Another difficulty was to move the working length of screw pipe of machine from one corner to another corner inside the plant. Also the machine was heavy, difficult to operate and the worm used in the machine was massive. As well as the cost of the machine was also very high which lead to increase the project cost of dry fermentation plant and it became difficult to be afforded. But this machine provided a base for development of the current machine and it is the first kind of machine which was developed for removal of bio-digested slurry from 10 feet depth below the ground.



Figure 2: Screw Press Machine for Lifting Bio-Digested Slurry Standing on Top of the Plant

After this another machine was tried for removal of bio-digested slurry (Figure.3.). In this a lifting system was used for emptying the plant which was used for boring of tube well. With this tripod stand and single phase motor was used for working. But this was also difficult to handle, expensive as it required at least four persons during the work. Migration of machine to other locations was also difficult and during the trail, accidental chances were observed.



Figure 3: Machine with Tripod Stand

After above trails of these machines, a small and compact semi -automatic system was developed, which was useful for lifting the bio-digested slurry from the plant. This Bio-Digested Slurry lifting machine was technically developed according to the dimensions and drawing of the paddy straw dry fermentation biogas plant. This removes the physical load as well as work load of labor. The labors feel comfortable with this machine and their work load was reduced as it required only two persons to operate machine. A single labor person requires in the digester for a short time of 15 minutes and the second person on the ground controls lifting machine by remote. The laborer inside the digester collects the bio-digested slurry in jaws and the machine lifts the material from the digester. The physical load required for passing of slurry is removed from this machine as well as the working difficulties. It was observed that by using the developed lifting machine, the complex difficulties and labor work was reduced, which leads to save time as it uses semi-automatic lifting processes. The machine set up is shown inFigure.4.



Figure 4: Bio-Digested Slurry Lifting Machine

In this mechanical set up, a single phase electric hoist having capacity of 500 kg, lift at a time for lifting the bio-digested was used. 3 mild steel pipe having diameter 3 inch and 10 feet long was arranged in a U shaped by digging a 6 inch diameter hole which was 2 feet long. The machine was tightly clamped with an upper pipe so as to remove chattering and vibrations in order to remove the causes of accidents.

3.4. Bio-Digested Slurry Lifting Machine Specifications

1. Electric Hoist

- Capacity of Lifting 500kg Per Lift.
- 1 H.P Single Phase Motor.
- 10 Meter Long Cable with Hook.

2. Mild Steel Pipe

- Three Pipes (3inch dia x 10 feet Long).

3. Clamping Jaws

- 5 feet Long with Jaws.

4. RESULTS

The Bio-Digested Slurry lifting Machine was under testing from past 8 months on 12 plants, having capacity of 16 quintal paddy straw with 4 quintal cow dung, located in Punjab Agricultural University and various other locations (fields). The machine was tested twice on each plant. The Results so obtained for bio-digested slurry lifting machine is as follows

4.1. Total Time Taken and Number of Lifts by Machine

The machine takes only 10 minutes to get ready for work. It is placed on the plant's top cover of 3 feet. Every time during operation number of lifts lifted by machine and time taken to empty the plant was noted. The material lifted by each lift was different, so the number of lifts could increase or decrease although working on the same plant. The bio-digested lifting machine was tested twice on each plant. The number of lifts and time taken are shown in Table 1.

Table 1: Total Time Taken and No. of Lifts During Removal of Bio-Digested Slurry

S. No.	No. of Lifts	Total Time Taken
Plant No.1	120	5 hour
	125	5 hour 10 min
Plant No.2	128	5 hour 10 min
	130	5 hour 10 min
Plant No.3	130	5 hour 20 min
	128	5 hour 20 min
Plant No.4	125	5 hour 10 min
	132	5 hour 20 min
Plant No.5	135	5 hour 30 min
	138	5 hour 30 min
Plant No. 6	130	5 hour 20 min
	132	5 hour 20 min

4.2. Weight Lifted by Each Lift

On average 120 to 135 lifts were made by machine. The capacity of the machine has up to 500 kg and material collected during each lift different weight. The weight was measured by weighing machine. It was observed that at initial level the slurry collected by jaws was of small quantity. It was due to a standing problem at the top. After emptying 1 feet of the plant, the labor could stand properly and collected the slurry as much as possible. It is shown in Table 2 that weight of bio-digested slurry continuously increases as the depth increases. The results obtained for per lift are shown in Table.2.

Table 2: Bio-Digested Slurry Lifted by Machine during Per Lift

S.No.	Material Per Lift (Kg)	S.No	Material Perlift (Kg)	S.No	Material Per Lift (Kg)	S.No.	Material Per Lift (Kg)
1	6.00	31	15.554	61	15.554	91	15.670
2	7.500	32	18.200	62	18.200	92	12.230
3	5.500	33	20	63	20	93	20.600
4	10.600	34	15.670	64	15.670	94	13.500
5	10.670	35	12.230	65	12.230	95	12.780
6	8.650	36	20.600	66	20.600	96	11.500
7	10	37	13.500	67	13.500	97	15.670
8	8.500	38	12.780	68	12.780	98	12.230
9	7.650	39	11.500	69	11.500	99	20.600
10	10	40	10	70	10	100	13.500
11	8	41	18	71	18	101	12.780
12	10	42	18	72	20.400	102	11.500
13	8.760	43	20	73	25	103	20.400
14	7.600	44	15	74	20	104	15
15	10	45	10	75	18	105	15
16	8.5	46	15	76	17	106	25.800
17	10	47	15	77	16	107	22.00

Table 2: contd.,							
18	12	48	25.800	78	17	108	20
19	10	49	22.00	79	18	109	11.500
20	8	50	20	80	22	110	15.670
21	15.670	51	20	81	18	111	12.230
22	12.230	52	25	82	20	112	20.600
23	20.600	53	30	83	22	113	15.670
24	13.500	54	20	84	25	114	12.230
25	15	55	13.500	85	13.500	115	20.600
26	10	56	12.780	86	15	116	13.500
27	15	57	11.500	87	16.600	117	25.800
28	15	58	10	88	13.500	118	22.00
29	25.800	59	18	89	15	119	20
30	12.780	60	20	90	16.600	120	11.500

4.3. Cost Comparison

At the end cost spent on every developed machine was also compared and it was observed that the cost incurred on Lifting Machine was less among all. The cost comparison is shown in Table 3.

Table 3: Costs of Different Machines has been Shown as Follows

S.No.	Screw Press Machine for Lifting Bio-Digested Slurry	Machine with Tripod Stand	Bio-Digested Slurry Lifting Machine
1.	Rs 70,000	Rs 45,000	Rs 12,000

CONCLUSIONS

- It is clearly observed that with this concept of lifting, the bio-digested slurry can be removed within 5 to 6 hours easily.
- The machine works according to conditions and the whole set up works properly.
- Accidental chance is almost negligible.
- The Bio-Digested Slurry Removal machine designed according to the drawing of paddy straw plant and the machine works properly during removal of bio-digested slurry.
- This concept is economical as comparison to other concepts, like hydraulics, conveyer type systems, due to high cost incurred in that.
- Due to nature of paddy straw material, this material can only be lifted not removed from worm technology.
- The system is mechanized and controlled by remote, the speed of the lift is a remote control and the speed does not arise accidental chances during the work.

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